multichannel systems

Temperature Controller TC01/02
Manual

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1 Introduction

1.1 About this Manual

This manual comprises all important information about the first installation and the proper usage of the temperature controller TC01 and TC02. It is assumed that you have a basic understanding of technical terms, but no special skills are required to read this manual.

Make sure you read the "Important Information and Instructions" prior to install or to operate this temperature controller.

2 Important Information and Instructions

2.1 Operator's Obligations

The operator is obliged to allow only persons to work on the device, who

- are familiar with the safety at work and accident prevention regulations and have been instructed how to use the device;
- are professionally qualified or have specialist knowledge and training and have received instruction in the use of the device;
- have read and understood the chapter on safety and the warning instructions in this manual and confirmed this with their signature.

It must be monitored at regular intervals that the operating personnel are working safely.

Personnel still undergoing training may only work on the device under the supervision of an experienced person.

2.2 Important Safety Advice

Warning: Make sure to read the following advice prior to install or to use the device and the software. If you do not fulfill all requirements stated below, this may lead to malfunctions or breakage of connected hardware, or even fatal injuries.

Warning: Obey always the rules of local regulations and laws. Only qualified personnel should be allowed to perform laboratory work. Work according to good laboratory practice to obtain best results and to minimize risks.

The product has been built to the state of the art and in accordance with recognized safety engineering rules. The device may only

- be used for its **intended purpose**;
- be used when in a **perfect condition**.
- Improper use could lead to serious, even fatal injuries to the user or third parties and damage to the device itself or other material damage.

Warning: The device and the software are **not** intended for medical uses and **must not** be used on humans.

Malfunctions which could impair safety should be rectified immediately.

High Voltage

Electrical cords must be properly laid and installed. The length and quality of the cords must be in accordance with local provisions.

Only qualified technicians may work on the electrical system. It is essential that the accident prevention regulations and those of the employers' liability associations are observed.

- Each time before starting up, make sure that the **mains supply** agrees with the specifications of the product.
- Check the **power cord** for damage each time the site is changed. Damaged power cords should be replaced immediately and may never be reused.
- Check the **leads** for damage. Damaged leads should be replaced immediately and may never be reused.
- Do not try to insert anything sharp or metallic into the vents or the case.
- Liquids may cause short circuits or other damage. Keep the device and the power cords always **dry**. Do **not** handle it with wet hands. Make sure the device and your experiment are set up in a way that makes it impossible that any liquid spills onto the device or drips into the device from the surface of the table.
- Do not short-circuit the outputs of the device.

Requirements for the installation and operation

Warning: Improper use (especially a **too high setpoint temperature** or an **inappropriate channel configuration**, for example, a too high maximum power) can lead to **overheating** the heating element. Overheating can lead to **fire hazards** and even **fatal injuries**. Only advanced users should edit the channel configuration and only with extreme care.

- Make sure that the device is **not** exposed to direct sunlight. Do **not** place anything on top of the device, and do **not** place it on top of another heat producing device. **Never** cover the device, not even partially, so that the air can circulate freely. Otherwise, the device may **overheat**.
- The connected heating elements produce heat and can get **hot** during operation.
- Do **not** touch the connected heating elements during operation and do **not** store flammable materials nearby.
- Check in regular intervals that the connected heating element does not **overheat**.
- Regard the **specifications** of the **connected heating elemen**t.
- Use and keep the device only in a dry environment. Fluids or damp air may damage or destroy the device. Spilled liquid can damage or even completely destroy the electronics of the instrument. Avoid it by all means.
- Edit the channel configuration **only** if necessary, and only with **extreme care**. Test new configurations under personal supervision before operating the instrument unsupervised.
- The **Maximum Power** of the **channel configurations** should **not** exceed a value that is safe for use with the connected heating element, the temperature protocol, and the experimental setup.

2.3 Guarantee and Liability

The *General conditions of sale and delivery* of Multi Channel System MCS GmbH always apply. The operator will receive these no later than on conclusion of the contract.

Guarantee and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use of the device.
- Improper installation, commissioning, operation or maintenance of the device.
- Operating the device when the safety and protective devices are defective and/or inoperable.
- Non-observance of the instructions in the manual with regard to transport, storage, installation, commissioning, operation or maintenance of the device.
- Unauthorized structural alterations to the device
- Unauthorized modifications to the system settings.
- Inadequate monitoring of device components subject to wear.
- Improperly executed and unauthorized repairs.
- Unauthorized opening of the device or its components.
- Catastrophic events due to the effect of foreign bodies or Acts of God.

3 Installation and Operation

3.1 Welcome to the Temperature Controller TC01/02 (Rev F)

Warning: Improper use (especially a **too high setpoint temperature** or an **inappropriate channel configuration**, for example, a too high maximum power) can lead to **overheating** the heating element. Overheating can lead to **fire hazards** and even **fatal injuries**. Only advanced users should edit the channel configuration and only with extreme care.

The temperature controller TC01/02 is used to control the temperature of a connected **heating element**. It is available with one or two output channels TC01 and TC02, respectively. Handling of both devices is similar and information in the TC01/02 User Manual applies to both.

The TC01/02 was designed for use with **Pt100** sensors, which allow a very precise temperature recording and control. Pt100 sensors feature the highest available accuracy and linearity over a wide temperature range. All heating elements that are part of products from Multi Channel Systems are provided with Pt100 sensors. Please see the user manuals of the heating elements that you are going to use for details.

The TC01/ TC02 uses a **Proportional-Integrator (PI) based technology**. The setpoint temperature is reached fast, and the accuracy is extraordinarily high. The outputs are galvanically isolated against ground, that is, the TC01/ TC02 does not interfere with the experimental setup.

The TC01/02 is a general purpose temperature controller for use of almost any kind of heating element. The PI coefficients are preset in the **channel configuration** defaults for MCS products. You can set up your own custom configurations to use the temperature controller for your specific heating elements. Preset configurations are available for use with the heating elements that are part of the following products provided by Multi Channel Systems MCS GmbH.

- **MEA1060-INV**: 60 channel preamplifier and filter amplifier for microelectrode arrays on **inverted** microscopes. The same channel configuration applies to MEA1060-INV-BC amplifiers.
- **MEA1060-UP**: 60 channel preamplifier and filter amplifier for microelectrode arrays on **upright** microscopes. The same channel configuration applies to MEA1060-UP-BC amplifiers.
- **PH01**: Perfusion cannula with heater and sensor.
- **TCW1**: Warming plate with heater and sensor.

Note: Multi Channel Systems can provide a channel configuration for your application on request.

The TC01/02 heats actively, but the cooling is passive. Therefore, the minimum temperature is defined by the room temperature. A room temperature beyond 5 °C is not recommended.

For advanced applications, the TC01/ TC02 can be remote controlled via the USB port. The actual temperature values can be read on the connected computer and saved as a text file. You can then import this file into your custom evaluation software, for example, to plot a temperature curve. You can also set up custom programs for applying automated temperature protocols to the connected heating element.

Advanced **hardware diagnosis** features ensure a superior experimental control.

3.2 Setting Up and Connecting the TC01/02

Provide a **power supply** in the immediate vicinity of the installation site.

1. Place the TC01/02 on a dry and stable surface, where the air can circulate freely and the device is not exposed to direct sunlight.
2. Plug the external power supply cable into the supply power input socket on the rear panel of the TC01/02.
3. Connect the external power supply to the power outlet.
4. (Optional, for recording temperature curves or remote control) Connect the USB cable to a free USB port of the data acquisition computer.
5. Connect the TC01/02 to the heating element. Use the cable that is delivered with the heating system or use a custom cable. The cable is plugged into the female D-Sub9 socket. (CH1 for channel 1, CH2 for channel 2, if you have a TC02).
   See also chapter "D-Sub9 Pin Assignment" in the Appendix.

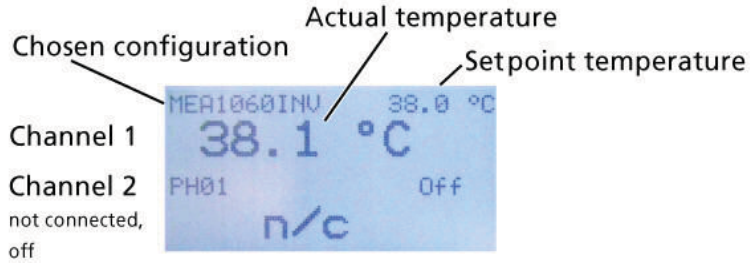
3.3 Operating the TC01/02

3.3.1 Starting the TC01/02

All functions are set in the **menu** of the TC01/02, including switching the TC01/02 on and off. If the TC01/02 is switched off, it goes into **standby-mode**. The instrument and display are only switched off completely when the TC01/02 is disconnected from the power supply. Most of the power consumption of 6 W in standby-mode is used by the power supply unit.

In the main menu on the display, select **On/Off**.
The TC01/02 starts to control the temperature on the selected channels immediately.
If the TC01/02 is connected properly, the actual temperature and the setpoint temperature are displayed in the **Temperature Control** view.

TC02 Display



3.3.2 General User Interface

The display shows the actual temperature and the setpoint temperature. You can enter the next menu levels by pressing the **Select** button. Go to a menu command with the **Up** and **Down** buttons and press **Select** to select the command highlighted by an arrow and to enter the next menu level. The functionality of the button array on the front panel is described in the following.

Up: Goes to the menu command **above** or **increases** the displayed parameter value. Tip once to increase the value in a small single step, press longer for larger steps.

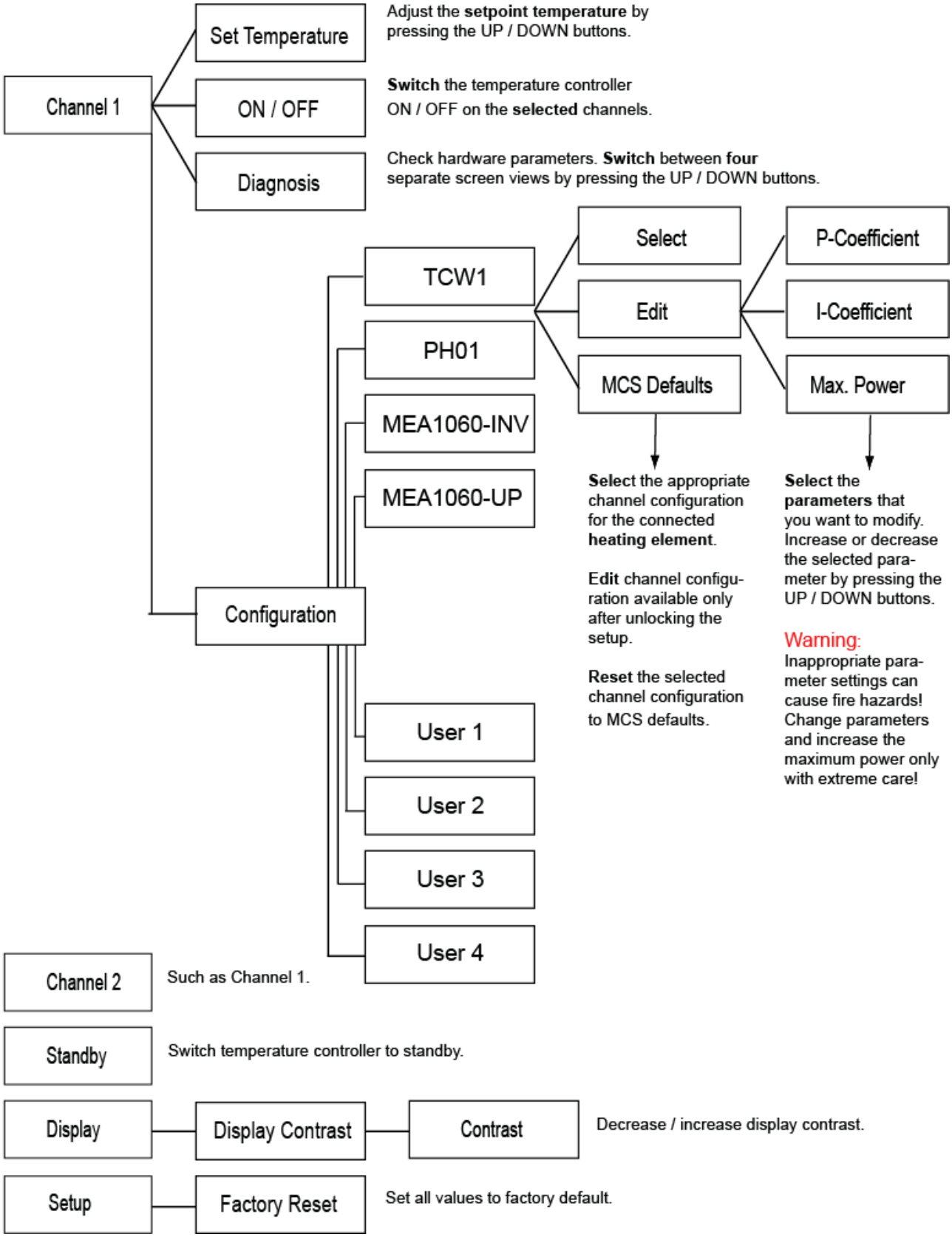
Down: Goes to the menu command **below** or **decreases** the displayed parameter value. Tip once to increase the value in a small single step, press longer for larger steps.

Select: Press this button to switch from **Temperature Control** view to the **Main** menu. Selects the command highlighted by an arrow in the menus and enters the **next menu level**.

Back: Leaves the menu level and goes **back** to the next higher menu level. Settings that were selected or modified are **applied** and **saved** automatically when leaving a menu.

3.3.3 TC01/02 Menus

Press the **Select** button to enter the **Main** menu. The other menu levels are shown in the following illustration.


Channel 1
Set Temperature
Adjust the setpoint temperature by pressing the UP / DOWN buttons.
ON / OFF
Switch the temperature controller ON / OFF on the selected channels.
Diagnosis
Check hardware parameters. Switch between four separate screen views by pressing the UP / DOWN buttons.
Configuration
TCW1
PH01
MEA1060-INV
MEA1060-UP
Select
Edit
MCS Defaults
P-Coefficient
I-Coefficient
Max. Power
Select the appropriate channel configuration for the connected heating element.
Edit channel configuration available only after unlocking the setup.
Reset the selected channel configuration to MCS defaults.
Select the parameters that you want to modify. Increase or decrease the selected parameter by pressing the UP / DOWN buttons.
Warning:
Inappropriate parameter settings can cause fire hazards! Change parameters and increase the maximum power only with extreme care!
User 1
User 2
User 3
User 4
Channel 2
Such as Channel 1.
Standby
Switch temperature controller to standby.
Display
Display Contrast
Contrast
Decrease / increase display contrast.
Setup
Factory Reset
Set all values to factory default.

3.3.4 Setting a Temperature

Important: Please note that there will always be an **intrinsic offset** between the setpoint and the actual temperature of the connected heating element, depending on the heating element used, the proximity of the sensor to the heating element, and the experimental setup. This offset needs to be determined empirically and taken into account when programming the temperature settings. The accuracy of the TC01/02 ensures that this offset remains stable in a fixed experimental setup, provided that the environmental conditions, for example, the flow rate, are not changed during the experiment.

1. Press the **Select** button to enter the main menu.
2. Move the arrow to the desired channel by pressing the **Up** and **Down** buttons, for example to Channel 1.
3. Press the **Select** button.
   The **Channel** menu is displayed.
4. Move the arrow to **Set Temperature** and press the **Select** button.
   The current setpoint temperature is displayed.
5. Modify the displayed value by pressing the **Up** and **Down** buttons.
6. As soon as you leave the menu, the new setpoint temperature is saved. If you do not press a button in the time range of a minute, the new setpoint temperature is also saved, and the screen is reset to the **Temperature Control** view.

3.3.5 Channel Configuration

Warning: Improper use (especially a **too high setpoint temperature** or an **inappropriate channel configuration**, for example, a too high maximum power) can lead to **overheating** the heating element. Overheating can lead to **fire hazards** and even **fatal injuries**. Only advanced users should edit the channel configuration and only with extreme care.

We recommend to use the factory-default settings for use with MCS products. You can modify these settings with the **Edit** command, if required. If you want to restore the factory-default settings, select the configuration that you would like to reset, and then select **MCS Defaults**.

For safety reasons, the **Edit** menu is locked each time the TC01/02 is switched off. You need to unlock it first by selecting **Unlock Edit** in the **Setup** menu.

The channel parameters are changed in the same way than the temperature. From the **Channel** menu, go to **Configuration**, select **Edit**, and then select the parameter that you would like to change, and modify it with the **Up** / **Down** buttons.

The following parameters can be modified:

- **Proportional gain**
- **Integrator gain**
- **Maximum power**

Example:

You are using a MEA1060-UP amplifier for upright microscopes on channel 1, and a perfusion cannula PH01 on channel 2 of a TC02. You have to configure each channel for the appropriate instrument. Select **MEA1060-UP** for **channel 1** and **PH01** for **channel 2** in the **Channel Configuration** menu of the TC02.

Note: The factory default parameters were optimized for an ambient temperature.
The configuration for use with the PH01 were optimized for a medium flow rate. Under extreme conditions, you may have to adjust the configuration for your experimental setup.

3.3.6 Hardware Diagnosis

This menu should be used for reviewing parameter settings or check the hardware performance in case that you observe any trouble with the instrument. Each channel can be checked separately. If the problem persists, please contact your local retailer. The highly qualified staff will be glad to help you. Keep the displayed information at hand when contacting customer support.

There are four separate screen views with different sets of information in the **Diagnosis** menu. You can toggle between the view by pressing the **Up** and **Down** buttons.

Diagnosis 1: Measured values

This diagnose screen view is used for checking the temperature sensor.

Temperature Actual temperature

Resistance 2 Cable resistance high side of sensor, see also chapter "D-Sub9 Pin Assignment".

Resistance 1 Cable resistance low side of sensor, see also chapter "D-Sub9 Pin Assignment".

Resistance X Sensor resistance plus cable resistance

Resistance S Sensor resistance

Board Temp Board temperature (The TC01/02 will switch off the channel outputs and go into stand-by mode when the board temperature reaches 90 °C.)

Diagnosis 2: Controller settings

This diagnose screen view is used for reviewing and checking the user settings.

Setpoint Temp Setpoint temperature

P Gain Proportional gain

I Gain Integrator gain

Max Power Maximum output power

Diagnosis 3: Controller output

This diagnose screen view is used for checking the operation of the internal controller.

Power Set	Output power set by the controller.
Power Out	Actual output power (product of **Current Out** and **Supply Voltage**)
Duty Cycle	PWM Duty cycle (internal value)
Current Out	Current through the primary coil of the isolating transformer
Supply Voltage	Supply voltage (from power supply)

Diagnosis 4: Heating element

This diagnose screen view is used for checking the connected heating element.

On/off	Current channel state
HE Voltage	Output voltage applied to heating element
HE Current	Output current applied to heating element
HE Resistance	Heating element resistance (voltage-current ratio)
HE Power	Output power delivered to heating element (voltage-current product), should be 80 - 90 % of **Power Out**, depending on heating element resistance)

3.4 Controlling the TCX via USB Port

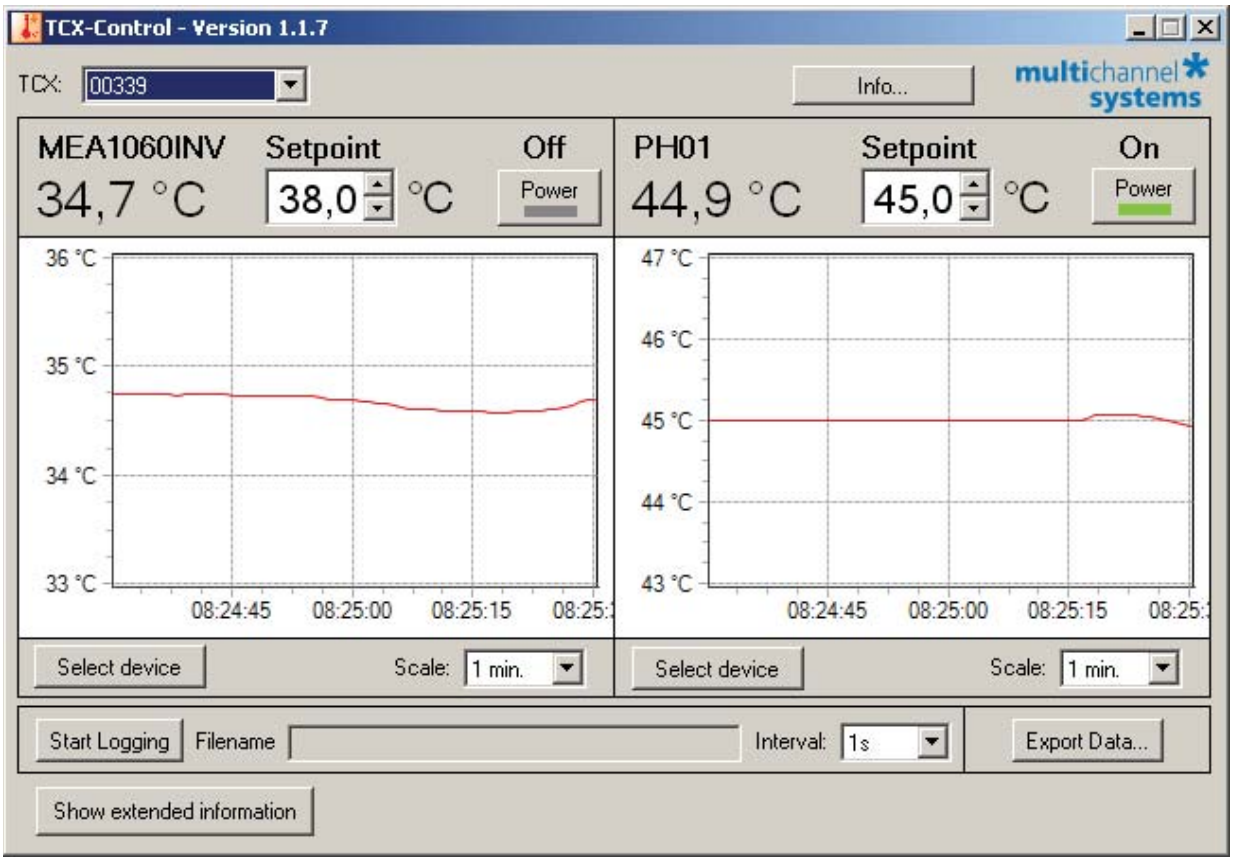
Instead of configuring your TC01/02 via the front panel controls, you can also connect it to a PC with standard USB cable and use the software **TCX-Control**. With this software, you can control all functions of one or more TC01/02 and it is also possible to read out the actual temperature values on your computer and save the data as a "*.txt" file. Then you can import this file into your custom evaluation software, for example, to plot a temperature curve. However, the TC01/02 is also **fully functional without** the USB interface.

3.4.1 Setting up the TCX-Control Program

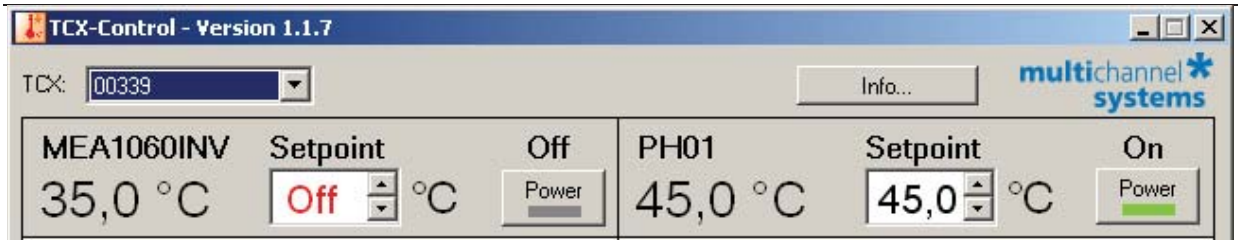
Connect the TC01/02 to a USB port of your computer. Start the setup program. This will install TCX-Control on your hard disk drive. Once you connected the TC01/02 to your computer via USB port, a hardware install dialog will appear. Follow the instructions on the screen to install the driver for the TC01/02.

General User Interface of TCX-Control

Below you can see the main user interface of TCX-Control. The **TCX drop down menu** shows the serial number of all connected temperature controllers. If you operate more than one TC01/02 at a time, you can select here which one you want to monitor.



Two windows show the temperature on the two channels. The scaling of the y-axis is adjusted automatically. The x-axis shows the absolute time taken from the system clock. The scale of the time axis can be altered in the **Scale drop down menu**. Find in each channel window a **Power** button to activate and deactivate the respective channel. The status Off / On is displayed.

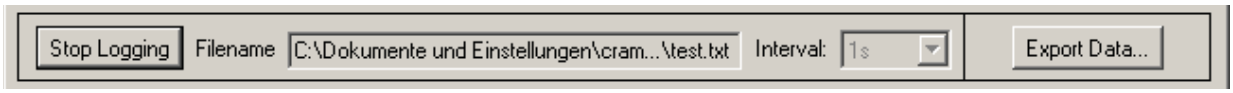


If a channel is deactivated, the status Off is displayed above the Power button. Additionally the status Off is displayed in red letters in the Setpoint drop down menu in exchange for the setpoint temperature.

The actual temperature is displayed as a number and plotted against time. There is also a selection field to adjust the **Setpoint temperature**. Under the **Select device** drop down menu, it is possible to select the type of instrument connected to the respective channel.

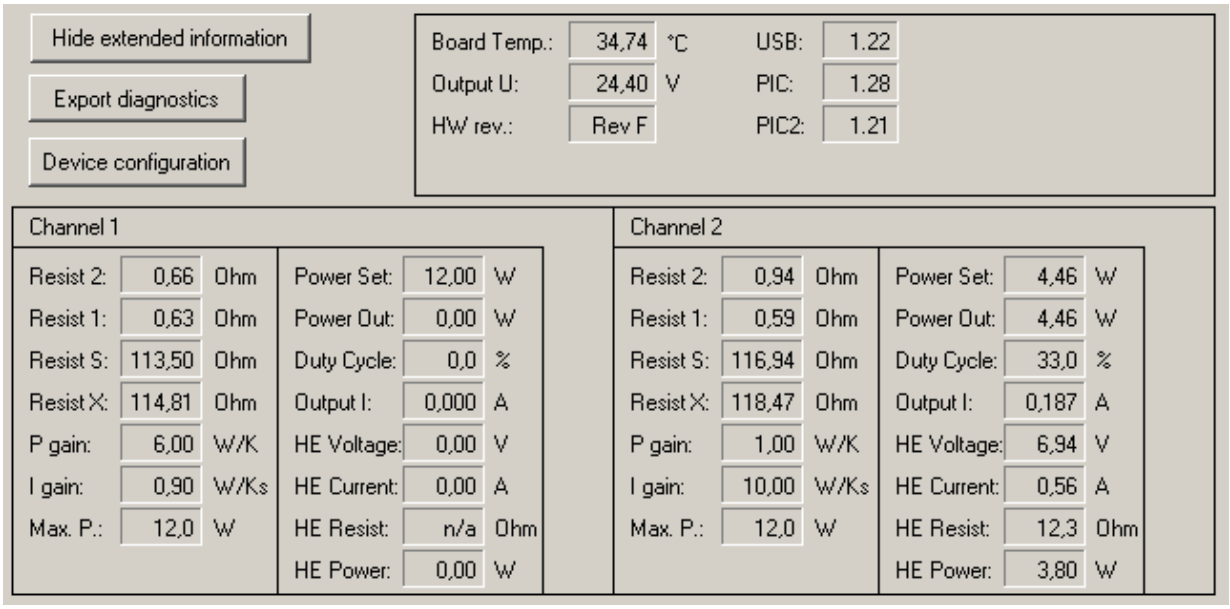
Temperature values can be logged to a temperature file. Select a time interval and a file name and press the **Start logging** button. Time and temperature values will be logged at the selected frequency. The extension of the file is "*.txt"

With the **Export Data** option it is possible to start temperature logging retrospectively. When pressing the Export Data button, all data from the memory of the TCX-Control software up to the present time is exported to a file. Memory starts when the TCX-Control (**NOT** the channel) is turned on. The memory holds a maximum of 24 hours of data. If the TCX-Control software has been running more than 24 at the time the export function is used, only the last 24 hours will be saved. The frequency is fixed to 1 second. The extension of the file is ".txt".

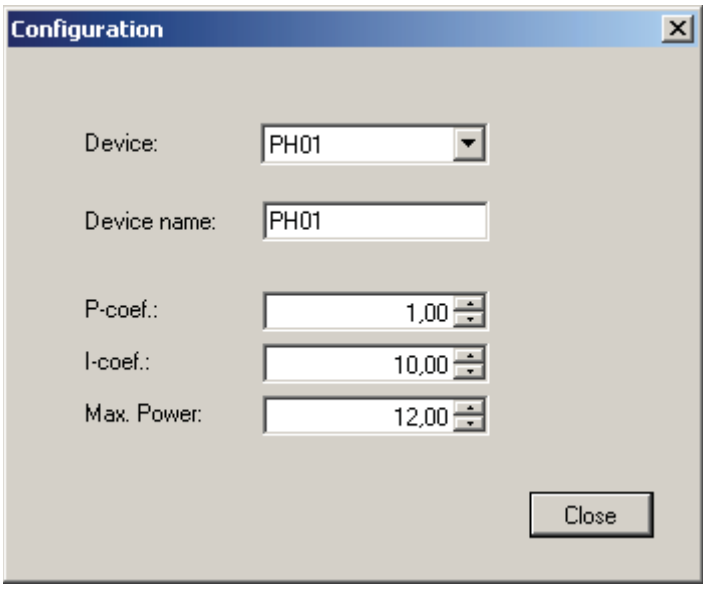


Extended Information

It is possible to display the extended information with all parameters from the TC01/02.
Click **Show extended information** in main menu.



These values can be saved to an ASCII file by pressing **Export diagnostics**. The default settings for P and I coefficients and maximum power for the different devices can be modified under **Device configuration**.



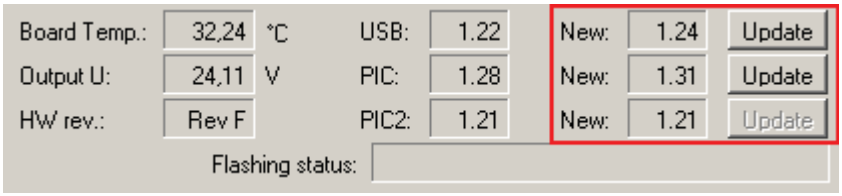
Firmware Upgrade

If you like to use a device from Multi Channel Systems MCS GmbH, which is not available in the settings of your temperature controller (for example, the TCW1), you need to upgrade the software and the firmware, and you have to reset in the TCX.

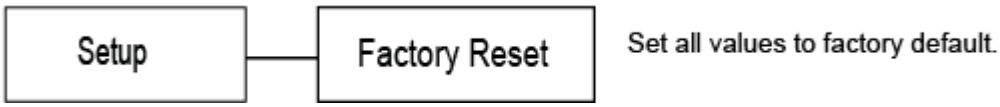
1. **Software**: Install the appropriate software version (for example, for TCW1, TCX-Control software Version 1.1.9 and higher).

2. **Firmware**: Click **Show extended information** in the main menu of the TCX-Control program.

Three additional windows appear, labelled with "New". Click the enabled buttons "**Update**" one after the other. The firmware is adapted automatically.



3. **Reset the TCX**: In the **main menu** display of the **temperature controller** select "Setup" and "Factory Reset" to apply the new firmware with MCS default settings for all devices, including TCW1 respectively.



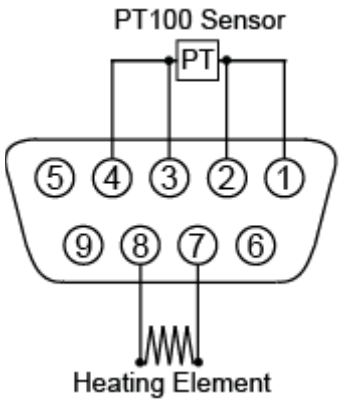
4 Appendix

4.1 D-Sub9 Pin Assignment

Pins **1 to 4** of the female D-Sub9 input connector should be connected to the **temperature sensor**, and **pins 7 and 8** to the **heating element**.

The other three pins are not needed for operation.

TC01 / TC02 : D-Sub Pin Assignment



Note: A **four-wire circuit** is required for use with **PT100 sensors**. Each of the two pairs assigned to pins 1/2 and 3/4 have to be connected together in **close** proximity to the PT100 sensor for proper operation. The current flows through the sensor from pin 1 to 4, and the voltage is measured between pins 2 and 3. The resistance between pin 1 and the sensor is measured as **Resistance 1**, and the resistance between pin 4 and the sensor is measured as **Resistance 2**, see also chapter **Hardware Diagnosis**.

4.2 Parameter Ranges

The setpoint temperature and the PI coefficients can be modified in the following ranges. The maximum power of the TCX is 30 W. If you connect a device with a maximum power less than 30 W, please decrease the maximum power to protect the device against destruction.

Parameter	Range
T	0.0 to 105.0
P	0.1 to 99.99
I	0.01 to 10.00
Power	0 to 30 W

4.3 MCS Default PI Coefficients

Note: The following PI parameters have been optimized at an ambient temperature of 25 °C, the PI coefficients for use with the PH01 at a flow rate of 3 ml/min. You may have to adjust these PI coefficients for your experimental setup, especially if the ambient temperature or the flow rate differ at large from those used by MCS. Using suboptimal PI coefficients can lead to an oscillation of the actual temperature, which is harmless, but may result in an unwanted behavior of the temperature controller.

	TCW1	PH01	MEA 1060-UP	MEA 1060-INV
P	60.00	2.00	4.00	6.00
I	75.00	2.00	1.50	0.90

4.4 Technical Specifications

Operating temperature	10 °C to 40 °C
Storage temperature	0 °C to 50 °C
Dimensions (W x D x H)	170 mm x 224 mm x 66 mm
Weight	1.5 kg
Main fuse	800 mA slow blow
Supply voltage and current	24 V and 4 A
Desktop AC Power Adapter	85 VAC to 264 VAC @ 47 HZ to 440 Hz
Sensor type	PT 100
Measuring method	four wire measuring bridge
Measuring temperature range	0 °C to 105 °C
Number of output channels	1 (TC01), 2 (TC02)
Output voltage	max. 24 V
Output current	max. 2.5 A per channel
Output power	max. 30 W per channel
Resistance of heating element	5 to 100 Ω
Control range	Ambient temperature (min 5 °C) to 105 °C
Control interface	USB 2.0

Note: Outputs are isolated against ground.